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Mr. E.R. Finn
Assistant General Counsel - Legal Proceedings
Law Division

SURGE VOLTAGE INVESTIGATION AT THE MOORE FARM

M.V. Lat

A monitoring study of transient voltages in the electrical system of a dairy farm has been carried out. The study was primarily aimed at recording transients in the grounding system that could appear as a touch potential in the cow barn. The recorded waveshapes do not indicate any abnormal transient voltages that could cause livestock problems.

1.0 INTRODUCTION

This report summarizes the results of a surge voltage recording study at the farm of Mr. B. Moore, near Lindsay in the Fenelon Falls Area. The study was initiated at the request of the Area Manager, as a result of several complaints by Mr. Moore.

The complaints are to a large extent concerned with livestock problems including miscarriages, deaths and physical disturbances (feeding problems, kicking, etc) and to a lesser extent with frequent failures of incandescent light bulbs. Mr. Moore attributes these problems to transient voltages originating from the Ontario Hydro power system.

An initial investigation in the fall of 1987 was not able to confirm the presence or to reveal a specific cause of any transient voltages on the DES or the BES that could cause these problems. However, because of the urgency of Mr. Moore's complaints, a decision was made to proceed with monitoring of the relevant voltages on the farm to determine if there are any transients and to provide clues to their origin.

A surge voltage monitoring study has been carried out over a period of four months using state of the art transient recording equipment. The results of the study do not indicate the presence of any abnormal transient voltages at the farm. Therefore, we conclude that electrical transients are not the source of Mr. Moore's livestock problems.

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2.0 MONITORING EQUIPMENT INSTALLATION

To monitor the voltages at the Moore farm we installed the Dranetz 656 transient recorder in the cow barn. The recorder was set up to measure the worst case "touch" voltage levels that would be experienced by the livestock in the barn, as well as to record any power line disturbances associated with the barn service panel.

Dranetz 656 records the complete waveform of any transient excursion of the power system voltage over a preset trigger level. There are two different trigger levels for each of the four channels, one for power frequency transients (RMS) and one for high frequency transients (IMP). Each event is then logged using an internal calendar clock and stored in the memory of the instrument. The stored events can be analyzed at a later date and stored on magnetic disk for permanent record. This and similar instruments are being used on a regular basis by the power utility industry and by associated industries for troubleshooting of transient voltage disturbance complaints.

As shown in Fig. 1, the recorder was installed in the immediate vicinity of the cow barn service panel and it was connected to monitor both legs of the 240/120 V supply with respect to the neutral, the neutral to ground voltage at the service panel and the voltage from the service ground electrode to a remote ground electrode. The remote ground electrode, consisting of a 1 m steel rod, was driven into the ground between the silos, diagonally opposite the location of the service panel, as shown in Fig. 1. This location for the remote ground was chosen to measure the maximum "touch" voltage that could be experienced by cows tied to the metal stanchions in the corner of the barn farthest from the service panel. Since the stanchions, and associated metallic water and milk lines are bonded to the service ground electrode, any surge voltages on the grounding system will have the greatest effect in this location.

A diagram of the electrical connections to the recorder is shown in Fig. 2. The recorder was located in a steel cabinet, fastened to the wall adjacent to the service panel. The electrical connections inside the panel included provisions for heating the cabinet during very cold weather and a temperature cutoff switch for isolating the recorder in the event of temperature build-up inside the cabinet.

3.0 CHRONOLOGY OF THE MONITORING STUDY

The transient recorder was installed at the barn on March 18, 1988. The trigger levels were set initially on a tentative basis, subject to being decreased or increased, pending the examination of the first week's data. These initial settings are listed in Table I below.

TABLE I

TRIGGER LEVEL SETTINGS OF THE TRANSIENT RECORDER
(All values are given in volts)

Channel	Measured Parameter	March 18 to March 25		March 25 to June 17	
		RMS	IMP	RMS	IMP
A	Phase A to Neutral	5.0	300	10.0	200
B	Phase B to Neutral	5.0	300	10.0	200
C	Neutral to Service Ground	10.0	50	10.0	150
D	Service to Remote Ground	0.5	50	0.5	24

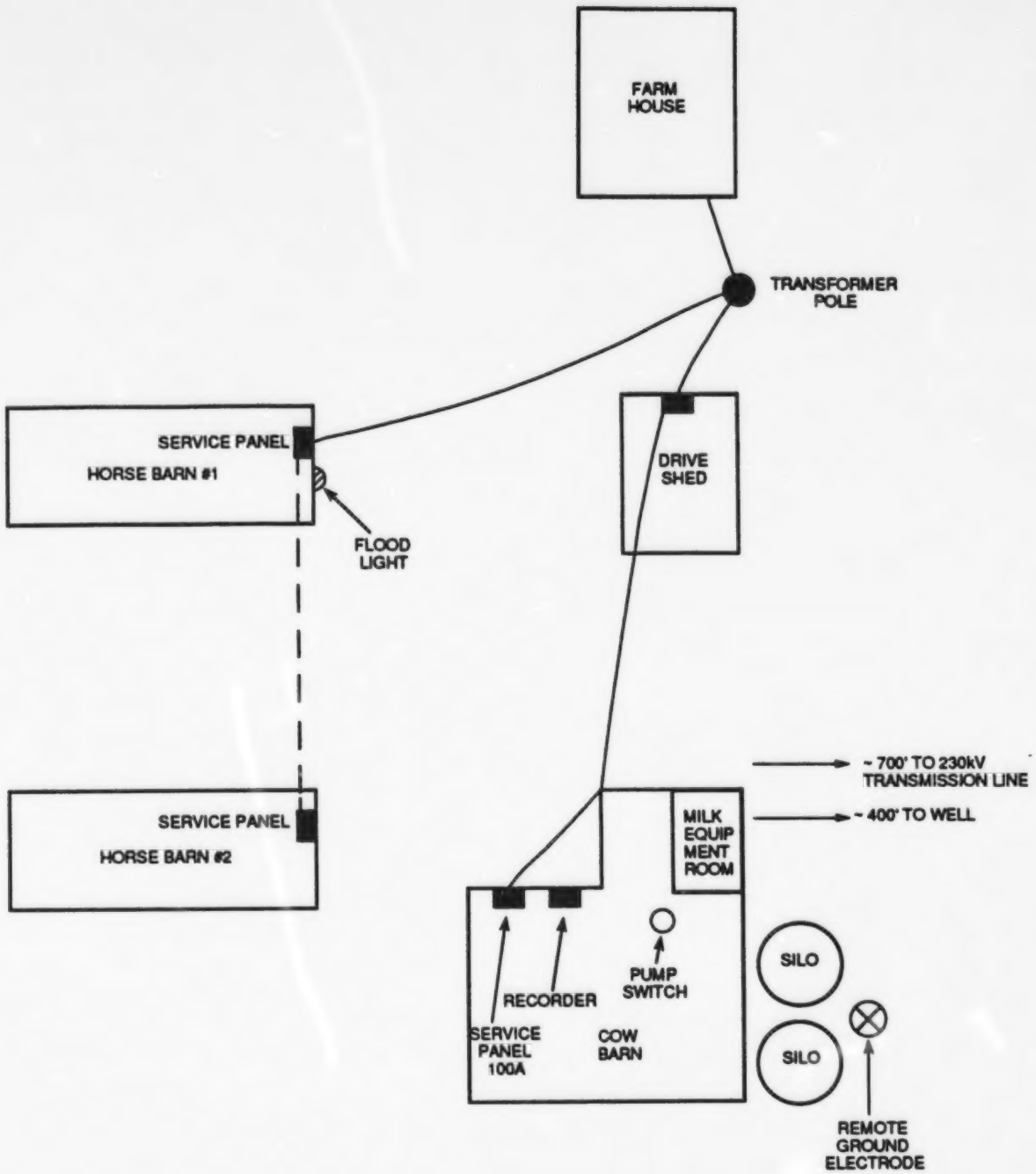

FIGURE 1

LOCATION OF TRANSIENT RECORDER WITH RESPECT BUILDINGS AND ELECTRICAL SERVICE EQUIPMENT

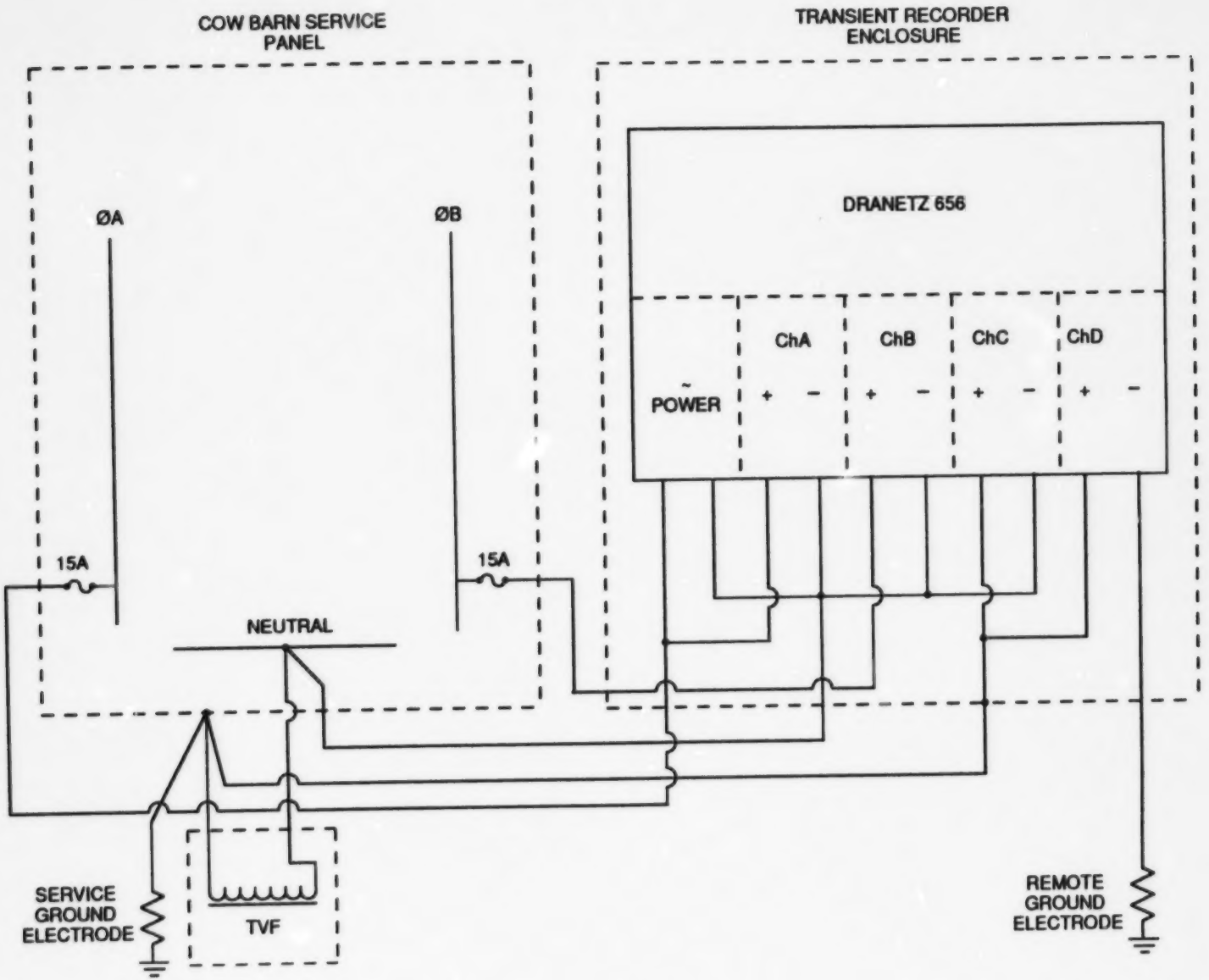

FIGURE 2

ELECTRICAL DIAGRAM OF TRANSIENT RECORDER CONNECTIONS

The data obtained in the period of March 18 to March 25 indicated that the phase voltage and neutral to ground channel trigger levels were set too low, and the instrument memory was on the verge of being overloaded. All of the data were either voltage dips caused by starting of electric motors in the barn (milking equipment and stable cleaner) or especially large voltage spikes on the neutral due to the normal operation of the submersible well pump which incorporates a capacitor starting circuit. The occurrence of these transients was concentrated in the periods of milking and cleaning in the barn, typically twice a day, in the early hours of the morning and in late afternoon. Since all of these transients were observed on the phases or on the neutral which are insulated from the exposed metal objects in the barn, they could not have caused any problems for the livestock in a properly wired installation. Consequently, such records were considered to have no value and they were eliminated by changing the appropriate channel trigger levels. At the same time, the trigger levels on channel D could be decreased to capture more of the critical data. The modified settings are tabulated in Table I as well.

The area staff then took over the operation of the transient recorder, and they would visit the farm every week to collect the recorded data and to inspect the equipment. In addition, they would ask Mr. Moore to provide the details of any problems during that week on the farm that might be related to the investigation. The only incident he reported in the course of this study was the blowing of a flood light bulb at the entrance to the horse barn and being kicked by a cow the following day.

The monitoring study was terminated on June 17, 1988. The transient recorder was then used to analyze the details of the individual stored records. All relevant records of transients recorded on channel D (service ground to remote ground) are listed in Table II. The Table II also lists any disturbances reported by Mr. Moore or noted by the Area staff.

Subsequently, the transient recorder was taken back to the farm on July 7, 1988 for one day to conduct a final check of the measuring circuit and to identify some of the on-the-farm transient sources. All major appliances and motors in the cow barn have been deliberately switched on and off ten times while recording any transients that would have occurred. Only the switching of the milking equipment and of the barn lights produced voltage dips that were of sufficient magnitude to be recorded, but only on one or two out of ten switching operations. The connections in the horse barn service panel and associated flood light circuit were checked by Mr. Moore's electrical contractor and were found to be in proper operating condition. All connections in the secondary service wiring were checked by the contractor and by Ontario Hydro line crew and were found to be in good condition. At this point all monitoring equipment was removed from the cow barn.

4.0 DISCUSSION OF RECORDED DATA

The recorded data was analyzed with the intent to discover links to the problems reported by Mr. Moore. As discussed previously (memo to R.J. Leveille dated Dec. 1, 1987) these reported problems were divided into three broad categories, namely; livestock disturbances, light bulb failures and well pump pressure switch failures. The analysis is therefore discussed with respect to these problems.

TABLE II

RESULTS OF VOLTAGE MONITORING PROGRAM AT THE BARRY MOORE FARM IN LINDSAY
VOLTAGES MEASURED FROM COW BARN GROUND ELECTRODE TO REMOTE EARTH

MONITORING PERIOD	EVENT#	DATE	TIME(EST)	TYPE	DISTURBANCE	GENERAL EVALUATION
MAR 18 - MAR 23	NONE					
MAR 23 - MAR 25	D1	MAR 23	19:46:28.53	IMP	NIL	SINGLE NARROW SPIKE 30 V x 2 μS
"	D2	MAR 24	13:53:09.82	IMP	NIL	SINGLE NARROW SPIKE 25 V x 2 μS
MAR 25 - MAR 31	D3	MAR 26	16:26:00.15	RMS	NIL	0.7 V (RMS) 60 Hz HALF CYCLE PULSE (8mS)
MAR 31 - APR 8	D4	APRIL 1	ESTIM 7:00	IMP	NIL	DETAILED RECORD LOST - 20 V BIPOLAR NARROW SPIKE
"	D5	APRIL 3	ESTIM 5:00	IMP	NIL	DETAILED RECORD LOST - 30 V BIPOLAR NARROW SPIKE
APR 8 - APR 15	D6	APRIL 14	16:59:41.10	IMP	NIL	SINGLE NARROW SPIKE 24 V x 1 μS
APR 15 - APR 22	D7	APRIL 18	03:42:08.68	IMP	NIL	SINGLE NARROW SPIKE 35 V x 1 μS
"	D8	APRIL 21	16:52:27.30	IMP	NIL	SINGLE WIDE SPIKE 0.8 V x 150 μS
APR 22 - APR 29	D9	APRIL 26	17:17:16.67	IMP	NIL	SINGLE NARROW SPIKE 12 V x 2 μS
"	D10	APRIL 27	06:26:42.08	IMP	NIL	NARROW SPIKE - 35 V x 2 uS AND 60 Hz PULSE - 5 V x 150 μS
APR 29 - MAY 6	D11	MAY 1	11:43:24.62	RMS	NIL	15 MINUTE INTERVAL OF 0.7V 60 Hz PULSES (MULTI-CYCLE) - WELDER ??
MAY 5 - MAY 13	D12	MAY 9	20:32:03.63	IMP	BULBS IN H-BARN	SERIES OF THREE NARROW SPIKES IN 10 MIN, 85 V MAX.
MAY 13 - MAY 20	D13	MAY 15	20:45:00.00	IMP/RMS	THUNDERSTORM	MANY SPIKES AND PULSES TO 21:55, SPIKE MAX. 160 V, PULSE MAX. 8 V
"	D14	MAY 16	15:33:00.00	IMP/RMS	THUNDERSTORM	MANY SPIKES AND PULSES TO 17:04, SPIKE MAX. 160 V, PULSE MAX. 5 V
MAY 20 - MAY 30	D15	MAY 24	13:13:40.98	IMP	NIL	FOUR NARROW SPIKES 24 V MAXIMUM, 1 μS WIDE, IN 50 μS INTERVAL
MAY 30 - JUNE 3	NONE					
JUNE 3 - JUNE 10	NONE					
JUNE 10 - JUNE 17	D16	JUNE 14	07:15.12.90	RMS	NIL	60 Hz PULSE 14 V 6 mS WIDE, FROM NEUTRAL, OFF FARM SOURCE
"	D17	JUNE 14	08:27:26.98	RMS	NIL	60 Hz PULSE 18 V 5 mS WIDE, FROM NEUTRAL, OFF FARM SOURCE

4.1 Livestock Disturbances

Livestock disturbances are the most serious of the problems reported. The only link between such disturbances and the electrical power system is the "touch" potential that could be measured across the animal contact points. In this particular case, the maximum potential would appear between the pipes and stanchions that are bonded to the service ground electrode, and the remote ground electrode. The channel D of the transient recorder was therefore connected between these two points to monitor and record any possible transients that might occur.

A summary of the recorded data from channel D is listed in Table II. There are 17 instances where transient voltages have been captured, and the types of transients can be broadly divided into three categories defined as follows:

i) Narrow spikes with relatively large voltage magnitude, lasting up to several millionths of a second. Typical spike is shown in Fig. 3, for event D12 on May 9. The spikes arise from various sources of electrical interference such as switching on and off of large appliances or lightning storms. For example, the capacitor starting circuit of Mr. Moore's well pump creates spikes up 200 V. These spikes are harmless and not likely to be even perceived by the animals because of their extremely short duration.

ii) Low magnitude (<1 V) pulses which can be created by switching of large appliances by other customers on the feeder and by distant faults on the distribution system. These types of transients are generally harmless since they are below the generally accepted continuous tingle voltage limit of about 1 V.

iii) Pulses exceeding the 1 V continuous tingle voltage limit have been observed on five separate occasions, on April 27, May 15, May 16 and on June 14 (events D10, D13, D14, D16 and D17 respectively). The pulse associated with the event D17 is shown in Fig. 4. These are usually produced by operation of protection devices (fuses, expulsion arresters and reclosers) on the distribution system as a result of lightning strikes or equipment failures. The number of such operations is well within the rate experienced on other parts of the Ontario Hydro distribution system. The rate that would be expected for a network like that supplying Mr. Moore's farm is about 50 operations/year.

It is possible that the cows would have felt the pulses that are identified in category (iii), however, such pulses have insufficient magnitude and rate of occurrence to have caused the problems reported by Mr. Moore. In fact, Mr. Moore reported no livestock disturbances coincident with these pulses. The pulse energy is very low, typically less than 0.01 J, a level that is comparable to the energy delivered by an electric fence or an electric cattle prod. Since these devices have been used by the farm industry for years with no known adverse effects we must conclude that the previously mentioned pulses are not the cause of Mr. Moore's livestock problems. Furthermore, no problems of a similar nature have been reported from any of the other 50 000 dairy farms in Ontario that are exposed to similar pulses.

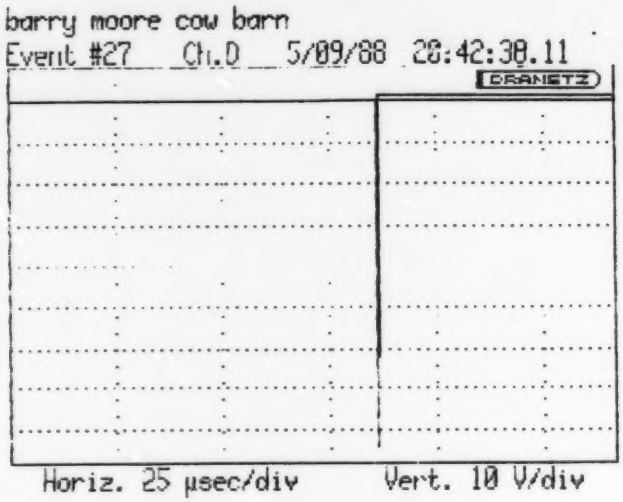

Figure 3

A typical record of a voltage spike
(Event D12, May 9, 1988)

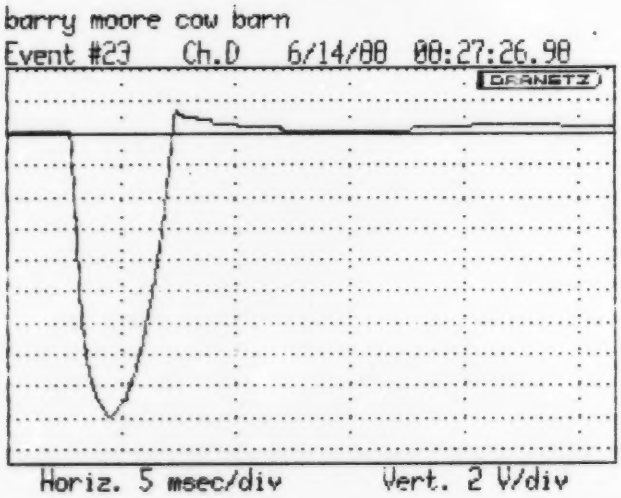

Figure 4

A large half cycle 60 Hz pulse
(Event D17, June 14, 1988)

4.2 Light Bulb Failures

Only one bulb failure was reported by Mr. Moore in the course of the monitoring study, on May 9. Since the time when this failure occurred is not known, it cannot be tied to any specific recorded event. The only event that occurred on that day was D12, and the transients associated with it would not have caused the light to burn out.

Typically the service voltage is at 120 V, but prolonged excursions to 124 V have been observed. These voltage levels are well within the CSA standard limits of 108V and 125 V (CSA C235-83). Since the service voltage is slightly higher than the average, ordinary 120 V light bulbs can be expected to fail at a slightly higher than average rate. Again, there are many other customers on the Ontario Hydro system that experience similar or even higher service voltages. Mr. Moore could be advised to use 130 V light bulbs, which are designed for rural service, as a remedy for his concern.

4.3 Well Pump Pressure Switch Failures

No failures of the well pump switch have been reported in the course of the study. None of the recorded transients could cause the switch failures reported by Mr. Moore. It should be noted that both the pump and the pump starter had been replaced several months prior to the beginning of the study.

The operation of the capacitor starting circuit of the pump creates substantial spikes in the electrical system of the farm, but these appear to be harmless to both the livestock and to the pressure switch.

5.0 CONCLUSION

A four month monitoring study of the transients in the electrical system of the farm of Mr. B. Moore near Lindsay has not recorded any harmful surges that could cause livestock disturbances or electrical equipment failures on the farm. The transients that have been recorded are generally typical of what could be expected in other farm installations in terms of their magnitudes, durations and frequency of occurrence. The livestock problems reported by Mr. Moore are therefore not caused by any part of the Ontario Hydro's power system.

Approved:

A.F. Baljet
Manager
Electrical Research Department

ME
MVL:TMAC

Submitted:

M.V. Lat
Engineer
Electrical Testing & Development Section
Electrical Research Department